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Geo-Engineering: A Vision for the 21st Century

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Front cover photo: The Schnabel Foundation Company built one of two underground rail stations for the St. Louis Metro Link light rail system near the St. Louis Centre. An open specification system for the complex excavation support project allowed Schnabel to complete the project on time and on budget./photo courtesy ADSC: The International Association of Foundation Drilling
Background photo: Nonwoven virgin polyester geotextile fabric magnified 200 times at the Scanning Electron Microscopy Lab./photo courtesy FHWA Turner-Fairbank Highway Research Center

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ABSTRACT

This report, *Geo-engineering: A Vision for the 21st Century,* documents recent actions by acknowledged U.S. experts in the geo-engineering related disciplines of civil engineering to define the role of geo-engineers and geo-engineering in the 21st Century. Approximately 50 of the nation's industry, academic, and public sector leaders met for a two-day synthesis session held at the Xerox Document University in Leesburg, Virginia. There, they addressed issues such as: 1) who are geo-engineers; 2) where should geo-engineering be in the larger civil engineering milieu; and 3) how should geo-engineering achieve the desired goals. From these discussions, a geo-engineering action plan that focuses on identity, education, research, contracting/procurement, and advancing the "state of the art" and improving the "state of practice" was developed. In addition, recommendations were made to expand the action plan so that it is international in nature. Participants debated formation of an integrating organization to begin implementation of the geo-engineering action plan. The report recommendations include convening an expanded international workshop within the next 12 months.

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ABSTRACT

This report, *Geo-engineering: A Vision for the 21st Century*, documents recent actions by acknowledged U.S. experts in the geo-engineering related disciplines of civil engineering to define the role of geo-engineers and geo-engineering in the 21st Century. Approximately 50 of the nation's industry, academic, and public sector leaders met for a two-day synthesis session held at the Xerox Document University in Leesburg, Virginia. There, they addressed issues such as: 1) who are geo-engineers; 2) where should geo-engineering be in the larger civil engineering milieu; and 3) how should geo-engineering achieve the desired goals. From these discussions, a geo-engineering action plan that focuses on identity, education, research, contracting/procurement, and advancing the "state of the art" and improving the "state of practice" was developed. In addition, recommendations were made to expand the action plan so that it is international in nature. Participants debated formation of an integrating organization to begin implementation of the geo-engineering action plan. The report recommendations include convening an expanded international workshop within the next 12 months.

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PREFACE

Prominent U.S. engineers practicing in the applied earth sciences set out to define a vision for their profession's future at a seminal workshop, held May 20-21, 1994, at the Xerox Document University in Leesburg, Va. This workshop was anchored on the premise that the role of 21st century geo-engineers seems destined to take on greater importance and consequence as human activity makes even greater demands on the earth for extraction of natural resources, transportation, work, and habitation.

The principal support for this workshop came from the National Science Foundation (NSF) and the Federal Highway Administration (FHWA). Both organizations were involved with the Civil Engineering Research Foundation's (CERF) High-Performance Construction Materials Program and wanted to increase attention to the importance of the geo-engineering community. As a result, CERF planned and executed the national workshop described in this report with the help of the newly-formed Geo: Materials and Systems Steering Committee. Members of this committee are listed in Appendix B and the front inside cover.

Along with NSF and the FHWA, other Federal agencies provided support as well. They are: the Army Corps of Engineers, Air Force Office of Scientific Research, and Department of Energy.

ACKNOWLEDGMENTS

The efforts of many geo-community experts went into the making of this report. We would especially like to thank the members of the Geo: Materials and Systems Steering Committee who donated many hours of their time and expertise in planning and execution of the workshop. Mehmet T. Tumay of the Louisiana Transportation Research Center and formerly of the National Science Foundation, Albert F. DiMillio of the Federal Highway Administration, and Peter H. Smeallie of Research Opportunities Management were at the forefront of the effort to establish the steering committee.

Other Federal agencies involved in planning the workshop include: the U.S. Army Research Office, Terrestrial Sciences Army; the Air Force Office of Scientific Research; and the Department of Energy.

Mel Hensey, of Hensey Associates, Cincinnati, Ohio, deserves special mention and credit for his leadership contributions as workshop facilitator. His expert guidance and numerous suggestions were invaluable assets in consensus building and workshop operations.

Many members of the steering committee provided substantive suggestions and comments to the drafts of this report. Among CERF staff who worked on this project, I wish to acknowledge the special efforts of Carl O. Magnell, CERF's director of research, who is the principal author. Richard A. Belle, CERF project manager, and Lisa Diehl, CERF research engineer, also helped to coordinate the workshop. CERF also acknowledges the critical review, supervision, and suggestions provided by CERF management staff. Finally, the assistance of Paul C. Knapp, CERF communications and education coordinator, Meg A. Willett, CERF technical writer, and Anna Mossaidis, CERF administrative assistant, in editing and report design and layout was invaluable and deeply appreciated.

Publication of this report was made possible, in part, through contributions by members of CERF's New Century Partnership:

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Harvey M. Bernstein

Harvey M. Bernstein, President
Civil Engineering Research Foundation

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EXECUTIVE SUMMARY

The expertise and experience of U.S. geo-engineers provide the essential foundation that the nation's other civil engineers build on. What should that foundation look like in the 21st century? This probing question challenged approximately 50 of the nation's leading geo-engineers during a May 20–21, 1994, workshop held at the Xerox Document University in Leesburg, Va.

There are mixed perceptions of what geo-engineering encompasses, and even what its proper moniker should be.

Before the experts brought together for the workshop could construct a vision for geo-engineering, they analyzed the current role of geo-engineering in the larger framework of civil engineering. Their professional perspective is simply that geo-engineering is a significant discipline and will become increasingly important in ensuring the future quality of life and economic prosperity of our nation and its citizens.

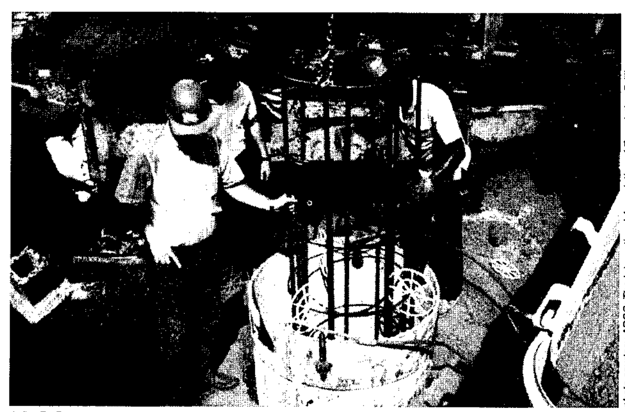
Workshop participants concluded that five issues are key to the future of geo-engineering: identity, education, research, advancing the state of the art/state of the practice, and contracting and procurement. For each of these issues, a vision, strategy, and action plans were developed.

Identity

There are mixed perceptions of what geo-engineering encompasses, and even what its proper moniker should be. Perception, image, and unity were thoroughly discussed at the workshop as identity was of prime concern to participants. To further establish and enhance the identity of geo-engineering, a vision, strategies, and action plans were laid out.

The vision: To unify geo-engineering so that its contribution to society is clearly recognized, and to establish geo-engineering as a leading civil engineering discipline in the 21st century.

To accomplish this, a three-pronged strategy was devised: 1) development of a name and mission that are recognized internally and externally, 2) a proactive public relations program, and 3) potentially, development of an umbrella or "integrating" geo-engineering organization.



ADSC conducted a drilled shaft inspectors school for the Alabama Highway Department.

The action plans that make this strategy work are outlined briefly. To develop a name, the following action steps were proposed: capture ideas from engineering, construction, and manufacturing communities; discuss this issue at a future workshop; and hold an appropriate competition for a name, and possibly, logo. A draft mission statement was crafted at the workshop, and, as part of the action steps, will be circulated within the geo-engineering community and designated a primary focus item at the next workshop. The public relations program calls for proactive, visible activities including workshops, informational brochures, geo-engineering-related magazine articles, as well as a long-term public relations effort that extends beyond the geo-engineering community.

Strategies and action plans for the development of an integrating organization were not enumerated, however, certain parameters were set forth. Among those are: conduct a meeting with leaders of key existing organizations to explore the need for an integrating organization, compile a list of relevant geo-engineering organizations, introduce and test the idea, and finally, if appropriate, develop steps to establish an organization. As seen throughout this report, the concept of an integrating organization derives from multiple perspectives and considerations.

Workshop participants decided the following five issues were key to the future of geo-engineering: identity, education, research, advancing the state of the art/state of the practice, and contracting and procurement.

Education

Dedication to quality was paramount during discussions of U.S. educational processes. Attracting the brightest high school graduates and continuing to update the skills of geo-engineers already practicing are two concerns of the geo-community. The need for more civil engineering technicians was also voiced.

The vision: Educate geo-engineers so they will be able to elevate and sustain the professional practice of geo-engineering in the 21st century.

The strategy to accomplish this vision is to develop a professional geo-engineering degree. To do this, the following actions were suggested: obtaining graduate level accreditation of geotechnical engineering, continuing education for geo-engineers, exposing faculty to geo-engineering work environments, developing ethics and business management courses, and continuing to emphasize professional registration.

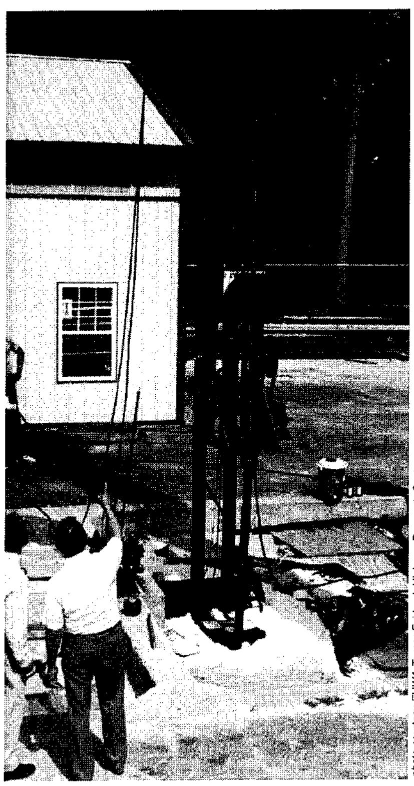


photo courtesy FHWA Turner-Fairbank Highway Research Center

Automatic pile-driving hammer for driving modal piles in the FHWA test pits is set up at Turner-Fairbank Highway Research Center.

Research

Research is inextricably linked to the other four fundamental issues. The state of the art and state of the practice are enhanced through the new technologies and practice methods resulting from research. Research requires educated and disciplined minds, laboratory facilities and funding. Research results will not be implemented until contracting and procurement procedures are modified; and finally, as research leads to increased knowledge and know-how, so too will the role geo-engineers play in the engineering environment. It is perhaps because of these connections that the research vision is broad and encompassing.

The vision: Through basic and applied research, particularly oriented toward multi- and interdisciplinary approaches, expand the fundamental understanding and knowledge base necessary to achieve national strategic objectives and address present and future geo-engineering challenges.

Establishing a principal research organization for geo-engineering-related research in the United States and implementation of geo-engineering research into practice are two research strategies to accomplish this vision. An action plan calls for developing a public awareness plan, identifying cutting edge technologies, establishing contacts at all levels of government, and identifying a lead organization to provide leadership for geo-engineering research.

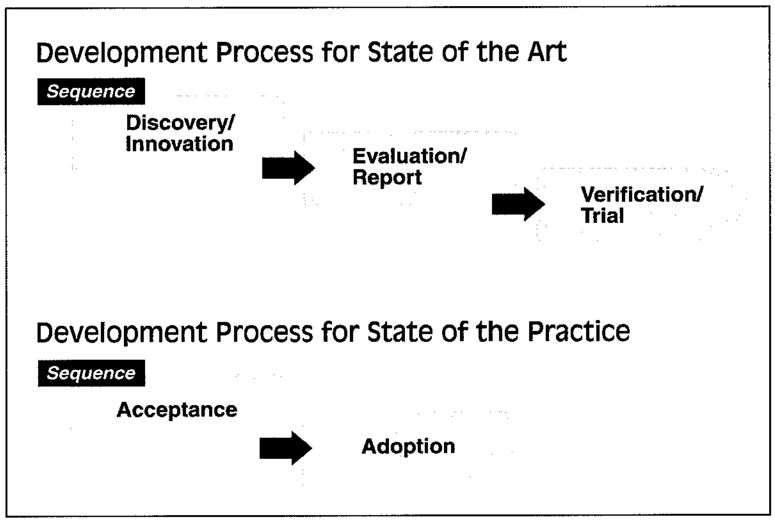
Advance State of the Art/Improve State of the Practice

Advancing the state of the art and improving the state of the practice require not only vision and strategies, but the perseverance to overcome numerous barriers. These barriers take many forms, including resistance to change, liability issues, lack of financial resources, lack of interdisciplinary cooperation, and incomplete bridging of theory and practice, to name a few. However difficult to surmount, these barriers certainly did not limit the vision of workshop participants.

The vision: To foster the state of the art and state of the practice, closing the gap between the two until no geotechnical reason exists that any project cannot be built on any site.

The vision is lofty but the strategy is common-sense: improve the geo-engineering process by identifying the barriers and modifying or facilitating the process to achieve efficiency and decreased cycle time, for example, through total quality management and empowering employees. A five-stage process that looks at how the state of the art and state of the practice are linked will provide the basis of the action plan. For each of the five steps, a number of activities are recommended. These steps consist of 1) discovery/innovation, 2) evaluation/development, 3) verification/trial, 4) acceptance, and 5) adoption, as shown in Figure 1.

Figure 1



Contracting/Procurement

Contracting and procurement practices must become complementary assets rather than liabilities in the quest for quality.

The vision: Drive the contracting/procurement process toward quality in the constructed project.

As the main strategy, all members and firms in the geo-engineering practice should take a leadership role in applying existing and emerging procedures for contracting/procurement in order to optimize quality and costs in the constructed project.

To accomplish this, nine action steps were drawn up and assigned to suggested lead organizations, or an integrating organization. These suggestions range from training young engineers and students about alternate project delivery methods to developing new procurement mechanisms.

Conclusion

Workshop participants considered the many internal and external influences on geo-engineering, and devised a strategy that, it is hoped, will enable tomorrow's geo-engineers to contribute in optimal ways to the civil engineering profession, the nation, and the world. The enthusiasm and commitment to change generated at this workshop will lead the nation's geo-engineering community toward the accomplishment of its objectives.

For the future, two tangible efforts were defined: first, the continued existence of the Geo: Materials and Systems Steering Committee (through the cooperative efforts of the National Science Foundation and Federal Highway Administration, among others) and a second, follow-on workshop, larger in scope and attendance with, as appropriate, an international perspective.

Geo-engineers have always prepared the groundwork for others; now they have established a foundation for their own visions.

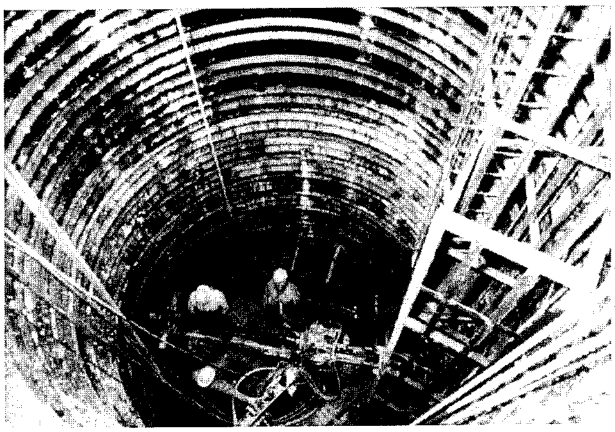


photo courtesy Hayward Baker Inc.

A new shallow cover bored tunnel was to run under a large research building in Sarnia, Ontario. Soilfrac grouting was performed inside two 30-foot deep shafts on each side of the building to reinforce soft clays and compensate for settlement caused by the tunneling.

Chapter One

INTRODUCTION

This report documents the results of a workshop held to focus attention on the future of engineering professionals practicing with/in materials and systems of the applied earth sciences, one of the fundamental disciplines that falls largely within civil engineering. Participants sought to reach consensus on internal issues, including what might constitute an acceptable and appealing label for the discipline. While there is agreement that "geo" is integral to any name, what complements "geo" remains the source of spirited opinion and discussion. In view of this, a working label for the discipline is "geo-engineering," and is used throughout this report.

The geo-engineering workshop documented in this report grew out of work performed by CERF as part of its proposed High-Performance Construction Materials and Systems (CONMAT) program.

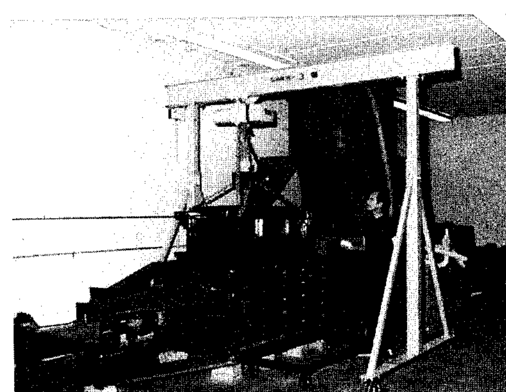
Overall, the workshop challenged participants to:

- Define a vision for geo-engineering
- Establish its desired role within the larger civil engineering profession
- Understand its broad impact on society and the nation

The 50 geo-community experts at the workshop analyzed the current role of geo-engineering in the larger framework of civil engineering in order to begin to construct a vision for geo-engineering. To facilitate articulation of the issues underlying the workshop objectives, participants framed the outcome in the context of the following questions:

- Who are we?
- Where are we now?
- Where do we want to be?
- How do we get there?

While perhaps simple in form, these questions provided the platform for an intense and probing assessment of geo-engineering by recognized leaders in the geo-community. These professionals' collective conclusion is simply that geo-engineering is a significant discipline and will become increasingly important in ensuring the future quality of life and economic prosperity of our nation and its citizens and our global interests.



A reinforced-clay soil specimen is loaded in a pullout box for a Louisiana Transportation Research Center project to evaluate the interaction properties of geogrids in cohesive soil.

1.1 Background

The geo-engineering workshop documented in this report grew out of work performed by the Civil Engineering Research Foundation (CERF) as part of its proposed High-Performance Construction Materials and Systems (CONMAT) program. The need for improved construction materials was identified at CERF's National Civil Engineering Research Needs Forum in 1991.

In April 1993, CERF, along with various public and private organizations, sponsored a symposium that launched the CONMAT program. At that time a report entitled *High-Performance Construction Materials and Systems: An Essential Program for America and its Infrastructure* (CERF Report 93-N5011), was distributed to President Clinton and Congress. This proposed program aims to fundamentally improve construction materials and associated systems in order to:

- Improve America's deteriorating infrastructure
- Increase productivity and improve U.S. competitiveness in the global market
- Increase economic prosperity and the general well-being of Americans

Because almost all construction is fundamentally impacted by soil conditions, it is important that geo-materials and systems achieve the same level of attention as manufactured construction materials such as concrete and steel.

The program involves planning and executing comprehensive research on high-performance construction materials and, of equal importance, expediting the commercialization of these new technologies.

This symposium was successful in initiating the process of coordinating research efforts for developing high-performance concrete, steel, aluminum, advance composites, and "smart" materials. During the following year, other materials joined the program, including roofing, coatings, asphalt, masonry, and timber.

Because almost all construction is fundamentally impacted by soil conditions, it is important that geo-materials and systems achieve the same level of attention as manufactured construction materials such as concrete and steel. To ensure that this objective was accomplished, and as a result of a request made by the National Science Foundation and the Federal Highway Administration, CERF planned and executed the national workshop described in this report.

1.2 Workshop Process

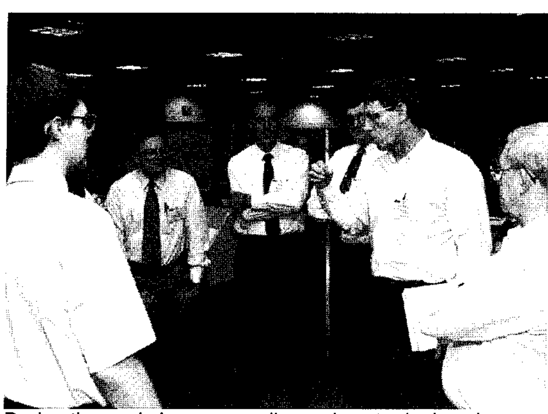


photo courtesy Xerox Document University

During the workshop, many discussions took place in smaller groups of individuals.

The workshop organizing committee engaged Mel Hensey as workshop facilitator; Mr. Hensey is a widely-recognized management consultant, civil engineer (geotechnical by discipline), and the author of *Collective Excellence: Building Effective Teams*. The steering committee and Mr. Hensey jointly developed the workshop process.

The workshop began with three keynote addresses focusing on the following challenge:

To evaluate the past and present status of geo-engineering, scrutinize challenges and future needs, and provide directions that will enable us to enter the 21st century as a vigorous discipline.

First, workshop director Ara Arman of Woodward-Clyde Consultants presented his thoughts on geo-engineering and encouraged geo-engineers to "soar higher" as a discipline. His complete remarks are included in Appendix D.

Harvey M. Bernstein, president of the Civil Engineering Research Foundation (CERF), outlined the workshop's theme and key objectives. He also explained CERF's ongoing work with the current Administration to stimulate the transfer of construction sector innovation into practice in the United States. These efforts include strong support for emerging programs such as the National Institute of Standards and Technology's Advanced Technology Program (ATP), the Construction Productivity Advancement Research (CPAR) Program of the Corps of Engineers, and the national goals proposed by the Construction and Building (C&B) subcommittee within the National Science and Technology Council (NSTC). The establishment of the C&B subcommittee in March 1994 indicates a growing recognition by national leaders of the importance of the design and construction industry to the nation's economic prosperity and well-being. The C&B subcommittee, while focused on constructed facilities, interfaces with other NSTC committees such as transportation, materials, manufacturing, health, safety and food, information and communications, and the environment and natural resources.

The workshop process was intended to capture broad individual insights and move toward collective themes.

The final keynote speaker was Dr. Thomas L. Anderson, AAAS Fellow at Rand's Critical Technologies Institute. Dr. Anderson's address, "Re-engineering Geotechnical Engineering," focused on the changes occurring in the Federal government and how geo-engineers need to embrace and exploit those changes. This includes Vice President Gore's *Re-inventing Government* initiative, which outlines how the Federal government plans to change contract delivery systems and procurement policies. Anderson also provided additional details about the role of the C&B subcommittee.

The C&B subcommittee collaborates with a variety of industry and professional organizations, using CERF as a focal point for these efforts. Through this collaboration, CERF assists the subcommittee in identifying opportunities and barriers for new construction technology development, suggests priorities concerning the Federal R&D budget as well as long-term national construction sector goals. Among the Clinton Administration's science and technology management principles, Anderson specifically mentioned the shift from defense to dual-use research, improved private sector access to technologies developed by Federal laboratories, and the role of Federal procurement to stimulate early use of new technologies. He emphasized that the geo-engineering community needs to be aware of these changes and incorporate them, as appropriate, and to be ready to re-engineer itself to succeed.

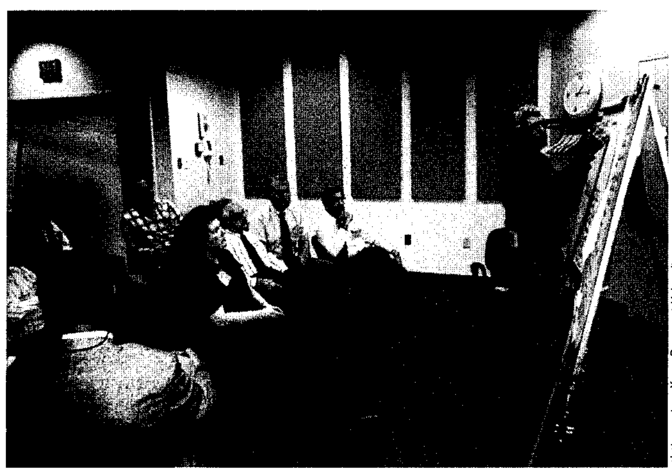


photo courtesy Xerox Document University

Workshop facilitator Mel Hensey writes down ideas from participants.

After these addresses, participants were divided into small "buzz groups," whose only task was discussion of pertinent geo-engineering topics. This led to a session where a new set of small groups discussed geo-engineering issues in greater detail. Finally, task groups developed strategies and action plans. This process was intended to capture broad individual insights and move toward collective themes. These themes, in turn, enabled the development of visions and goals and led to the eventual formulation of strategies and action plans.

As workshop participants attempted to define the role of geo-engineering within the civil engineering profession, they covered many subjects, including research priorities and benchmarks, obstacles to geo-engineering interaction with other civil engineering disciplines, fragmentation within the geo-engineering disciplines, increasing geo-engineering's visibility, expediting technology transfer and commercialization, and increasing awareness of geo-engineering's benefits to the design and construction community and the public.

As those attending the workshop focused on their discipline, they also looked at factors influencing the 20th century.

Of special concern was the perception that the design and construction process is less than optimal, due in part, perhaps, to inadequate focus on geo-materials and systems issues. This lack of attention also appears to impact the scope and focus of geo-engineering R&D. This could be due to a lack of coordination, the absence of a national program that focuses on geo-engineering, and the relative lack of visibility of the geo-community. A key workshop objective was to determine whether a national center or equivalent concept is needed to coordinate research, development, and evaluation of products and processes.

1.3 Examining Future Trends

As those attending the workshop focused on their discipline, they also looked at factors influencing the 20th century. These factors provide the imperative for action as well as the basis for charting the actions necessary for the emergence of geo-engineering as a vigorous, valued, and respected discipline in the 21st century. The most important factors are:

- Advances in science, engineering, and automation, including the information revolution
- The growing focus on the environment
- A renewed national focus on infrastructure, construction, and buildings

Finally, important developments within the larger framework of the U.S. construction sector will impact geo-engineering. Chief among these are the emerging recognition by the nation's leadership of both the impact and importance of the construction sector, the nation's largest manufacturing industry (and the second largest economic activity after health care) and the compelling need for marked performance improvements in this sector.

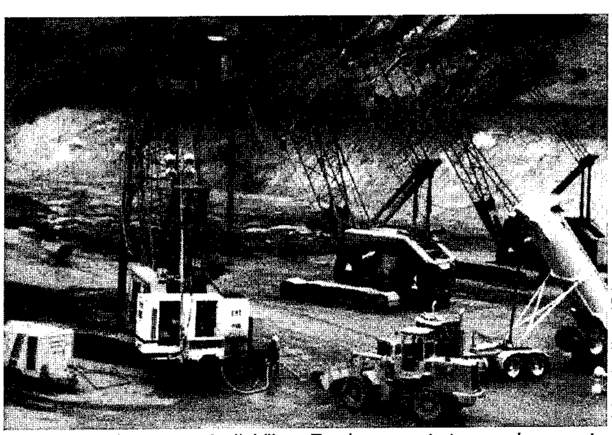


photo courtesy Hayward Baker

Hayward Baker crews built Vibro-Replacement stone columns at this Ox Mountain, Calif., landfill troubled by soft, liquefiable soils.

In sharp contrast to other major industries, construction lags in its current ability to innovate, increase productivity, improve quality, and cut costs. These issues are now being addressed, most notably through the NSTC. The NSTC's Construction and Building (C&B) subcommittee has recently proposed comprehensive national objectives for the construction sector, including:

- 50 percent reduction in project delivery time
- 50 percent reduction in operations/maintenance costs
- 30 percent increase in facility comfort & productivity
- 50 percent fewer building-related illnesses and accidents
- 50 percent less waste and pollution
- 50 percent greater durability and flexibility
- 50 percent reduction in job-related illness and accidents for construction workers

With these challenges and future trends in mind, workshop attendees better defined the current status of geo-engineering as a discipline, formulated a future vision of geo-engineering, and developed strategies and action plans to achieve that vision.

Workshop participants considered the many internal and external influences on geo-engineering, and devised a strategy that should enable tomorrow's geo-engineers to contribute in optimal ways to the civil engineering profession, the nation, and the world.

Geo-engineers are integral to all construction projects. For example, they will be remembered for their major role in one of the 20th century's extraordinary feats of engineering—the English Channel Tunnel. The Channel Tunnel will link countries, businesses, and people across what was once a barrier to trade and travel. In a smaller, but no less vital context, the efforts of this workshop and its participants will be recognized in years to come as a valuable step for geo-engineering and geo-engineers. Just as the Channel Tunnel promises to provide a closer link between countries and people, workshop participants formulated the basis for stronger links within the geo-engineering discipline, with the civil engineering profession, and the greater public and private community.

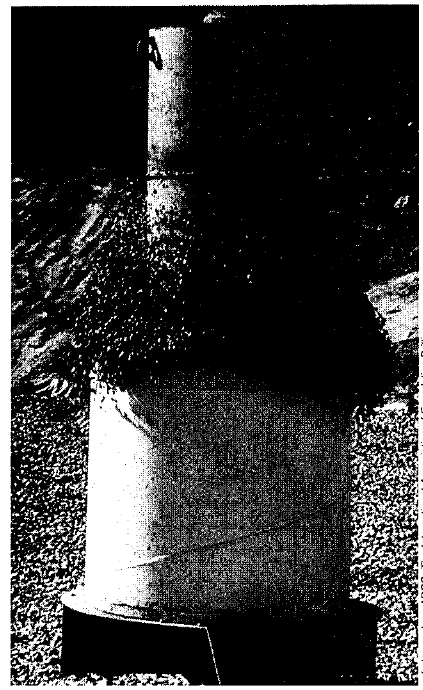


photo courtesy ADSC: The International Association of Foundation Drilling

The statnamic test was developed by Berminghammer Corp. to meet demands for a more cost-effective, less time-consuming method of determining the load carrying capacity of caissons and large diameter piles.

Chapter Two
IDENTITY

As noted in the introduction, the primary workshop objectives were to define the role and direction for geo-engineering in the 21st century. These objectives stem from the mixed perceptions of geo-engineering, including what the proper name for this fast-evolving discipline should be and what geo-engineering encompasses.

The steering committee concluded that workshop attendees, selected from among the recognized geo-related leaders in industry, academia, and the public sector, must not focus only on future directions but, indeed, authoritatively define the discipline. To aid in this quest, the workshop was framed in the four questions noted in the preceding chapter, namely:

- Who are we?
- Where are we now?
- Where do we want to be?
- How do we get there?

Who are geo-engineers? The term seeks to capture, in a more encompassing sense, the growing sphere of influence of engineering professionals who deal with geo-materials (both natural and man-made) and systems.

2.1 Who Are We?

Who are geo-engineers? The term seeks to capture, in a more encompassing sense, the growing sphere of influence of engineering professionals who deal with geo-materials (both natural and man-made) and systems. While geo-engineering is thus defined, most workshop attendees also emphasized that geo-engineers currently comprise a special discipline of professionals, largely represented within civil engineering, not a separate profession. The parameters of this special discipline remain to be defined, perhaps in a larger, future geo-engineering workshop.

The Scope of Geo-engineering

Important steps to define the scope of geo-related activities have both preceded and complemented this workshop. The former Geotechnical Board of the National Research Council, for example, considered this issue in 1989, concluding that 11 areas comprise the scope of geotechnology:

- Foundation engineering
- Mining engineering
- Tunneling technology
- Slope stability and landslide remediation
- Earth retaining structures
- Earthquake seismology and engineering

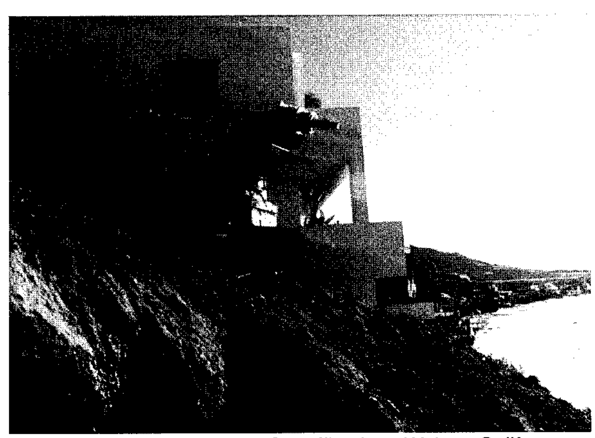


photo courtesy ADSC: The International Association of Foundation Drilling

In Southern California, D. J. Scheffler, Inc., Walnut, Calif., works on a hillside job.

- Dam engineering
- Control of solid and hazardous waste
- Disposal of radioactive wastes
- Subgrades
- Ground shock

The Geotechnical Board further concluded that these, in turn, provide geotechnology with a vital role in the following national issues: waste management, infrastructure development and rehabilitation, construction efficiency and innovation, national security, resource discovery and recovery, mitigation of natural hazards, and frontier exploration and development.

The American Society of Civil Engineers (ASCE), through its Geotechnical Engineering Division (GTD), is working to define a scope for geotechnical activities through its committee structure. The GTD Executive Committee has drafted a three-year strategic plan for the Geotechnical Division that incorporates a mission statement and 10 objectives. Executing the strategic plan will involve the Division in some new types of activities. The GTD, for example, has not previously been involved in efforts specifically directed toward improving education or improving professional practice.

The GTD draft document identifies the following technical committees: computer applications, deep foundations, earth retaining structures, embankment dams and slopes, engineering geology, environmental geotechnics, geophysical engineering, geotechnical safety and reliability, grouting, rock mechanics, shallow foundations, soil dynamics, soil properties, and soil improvement and geosynthetics.

What the workshop participants outlined as the scope of geo-engineering activities captures the insights of both the Geotechnical Board and ASCE's Geotechnical Engineering Division albeit within a different verbal context. The activities comprise eight applications:

- Geo-environmental systems
- Foundation systems
- Ground improvements
- Underground space and autonomous excavation
- Site characterization/reconnaissance
- Geostructure construction
- Technology transfer
- Links to geoscience

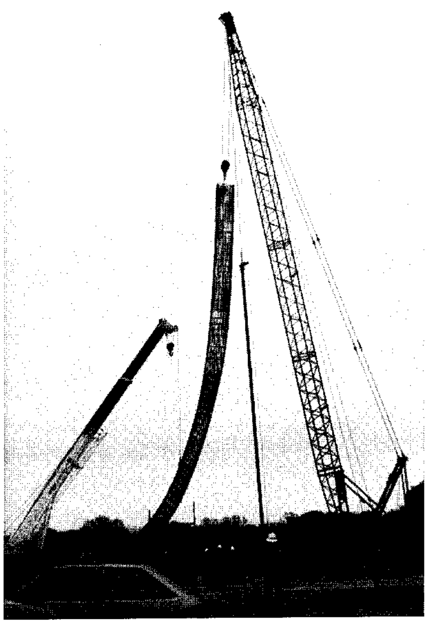


photo courtesy ADSC: The International Association of Foundation Drilling

A rebar cage is lifted into place.

Geo-engineering, through these components, clearly becomes a comprehensive civil engineering-based discipline that encompasses the breadth of civil engineering activities on and beneath the terrestrial surface. Geo-engineering, in this sense, is that discipline within civil engineering that provides the foundation on which other civil engineering disciplines build.

2.2 Where Are We Now?

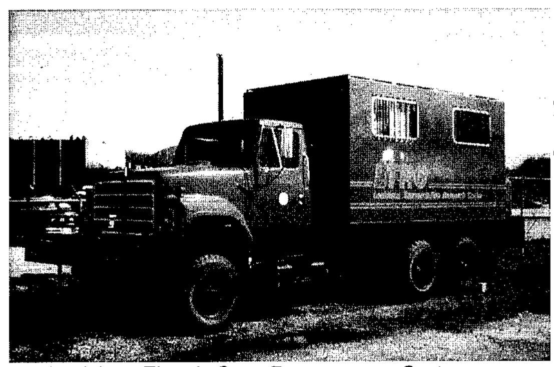
The answers that emerged from considering this question were diverse and problematic. The workshop consensus notes that geo-engineers are too often subsumed within the larger practice of civil engineering. This less than flattering self-portrait emerged as a principal difficulty confronting geo-engineering professionals. Moreover, the consequence of this perceived condition (i.e., the subsumed "voice" of geo-engineers) was defined as leading to less than optimal design, and often, constructability problems.

Why this distressing image? Many factors were suggested, chief among them are the fragmented nature of geo-engineering and the lack of a clear identity. With respect to identity, those in attendance suggested that this problem is rooted in the lack of visibility to others, since the geo-engineer is seldom the lead professional in construction activities.

2.3 Where Do We Want to Be?

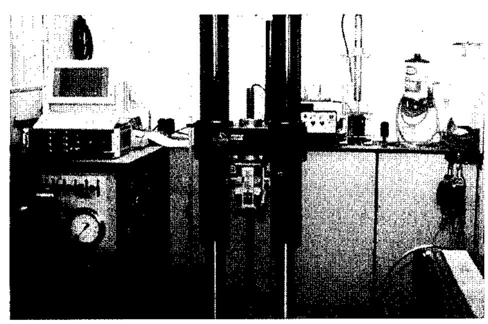
This question provoked a broad range of responses, reflecting perhaps the varied backgrounds of workshop participants. Notwithstanding this, one central theme emerged, namely that geo-engineers and geo-engineering be accorded their rightful place as an indispensable member and discipline of the larger civil engineering "team" and civil engineering practice. Important components were identified that, collectively, would serve to help geo-engineers and geo-engineering attain their rightful place on the team. These components include:

- A clear geo-engineering vision, a cooperative attitude, and unity
- Long-term strategic goals
- Incentives for research and a focus on innovation
- An active focus on quality and risk reduction
- A broad understanding of other disciplines and specialties
- Proactive communication
- Strong linkages to industry, academia, and the public sector



photos courtesy Louisiana Transportation Research Center

The Louisiana Electric Cone Penetrometer System (LECOPS) shown above has been implemented successfully in the field in connection with projects dealing with site investigation and pile capacity design and prediction. The LECOPS interior, shown below, is equipped with penetrometer probes, a depth encoder, and data acquisition hardware and software.



The Vision

Workshop participants defined a bold, comprehensive vision:

To unify geo-engineering so that its contribution to society is clearly recognized, and to establish geo-engineering as a leading civil engineering discipline in the 21st century.

The vision clearly posits that important steps must be undertaken by the geo-engineering community to improve its present situation. These steps were defined through specific goals and strategy components.

Goals

Three important goals were identified as essential for vision accomplishment. They are as follows:

- Society will recognize the value of geo-engineers, and how geo-engineers contribute to the nation's quality of life
- Geo-engineers will become leaders, integrators, and facilitators in engineering and construction
- Geo-engineers will be on equal footing with all engineers and professionals

Strategy

Goals and achievement depend on a carefully crafted and executed strategy. The initial components of such a strategy were shaped around three parameters, namely: development of a name and mission that are recognized internally and externally, a proactive public relations program, and the potential development of an umbrella geo-engineering organization.

Does "geo-engineering" convey the desired image?

Name and Mission

Does "geo-engineering" convey the desired image? Is it a term that is likely to garner the appropriate professional and societal recognition? Moreover, how is the multiplicity of tasks assigned to geo-engineers best defined? While the focus group session did not come to closure on these important issues, members concluded that a two-fold strategy should be recommended, a strategy that would:

- Select a name (perhaps geo-engineering) that is recognized both internally within the civil engineering profession and externally, among other engineers and within society, in general
- Develop a mission statement that reflects the focus and charge of this discipline

Steps toward the accomplishment of these tasks were likewise recommended. With respect to defining and gaining name acceptance, several recommended actions were put forth, including:

- Capture ideas from engineering, materials, construction, and manufacturing communities
- Assign as a principal topic at next workshop
- Stage an appropriate competition for a name and, possibly, a logo


photo courtesy Hayward Baker Inc.
Water seepage through a Colorado dam is prevented by injecting a cement grout curtain.

Two actions were recommended for the further development of a geo-engineering mission statement. First, the development and circulation within the geo-engineering community of a draft mission statement for general comment and, second, referral as a primary focus item at the next workshop. To this end, members drafted the following initial mission for geo-engineering:

We are dedicated to providing services, products, and constructed systems . . . to control forces of nature and use its materials in concert with man's (materials) for the benefit of society.

Public Relations Program

The proposed public relations program addresses primarily the geo-engineering community itself, or rather, what focus group members identify as comprising the geo-engineering community. An over-arching impression emerged that professionals practicing in geo-engineering do not necessarily identify themselves as "geo-engineers," and thus lack the stronger identification that exists for their structural, environmental and water resource peers.

For this reason the public relations thrust has to be, first, an internal thrust to promote unification and identity to geo-engineers themselves. Second, it must develop a sense of pride and achievement among geo-engineers.

The success of such a program rests upon proactive, visible action steps. These actions include: making use of journals, workshops, brochures, geo-engineering related magazine articles and, for the long-term, public relations efforts that extend beyond the geo-engineering community itself. The composite set of actions, as proposed, includes:

- Use existing geo-engineering and other suitable channels to disseminate and promote results of this workshop (for example, USUCGER, International Geosynthetics Society, American Society for Testing and Materials, Deep Foundations Institute, *Geotechnical News*, *Civil Engineering*, and *Engineering News-Record*)
- Change the name of the current journal
- Make the journal practice-oriented through a focus on case histories
- Convene, through the Civil Engineering Research Foundation, a larger national/international workshop (as well as regional workshops) to further develop and implement geo-engineering strategies
- Develop promotional brochures
- Develop a long-term media campaign utilizing multiple venues such as video, television, magazines, and multimedia, as appropriate
- Inform the public of geo-engineering's crucial role in disaster awareness and hazard mitigation
- Develop junior high and high school demonstrations and competitions as long-term initiatives to interest young people in geo-engineering as a discipline

photo courtesy Hayward Baker Inc.

Vibro-Compaction was used to densify sand and silty sand to a depth of 65 feet to reduce settlement beneath heavy tanks and mill equipment at a paper mill in Kamloops, British Columbia.

An Integrating Organization: A Potential New Cross-cutting Focus for Geo-engineering

How can existing professional and industry organizations better serve geo-engineers and the geo-engineering community? This issue surfaced in various formats throughout the workshop. The internal restructuring of existing organizations as well as forming external alliances were brought up as possible solutions. The American Society of Civil Engineers (ASCE), for example, is currently considering several mechanisms to strengthen its Technical Divisions, including the Geotechnical Engineering Division.

A group of workshop participants considered the "value added" of a specific integrating organization, an organization that would not usurp, but rather facilitate and coordinate the ongoing efforts of those existing professional and industry organizations whose interests encompass, but do not necessarily focus on geo-engineering. Clearly, the precise role and function of such an organization need to be defined, if indeed the decision to form this type of organization is made.

This group of workshop participants made several important decisions. They selected David Thompson of Haley & Aldrich, Inc., Cambridge, Mass., to lead this initiative. Peter H. Smeallie of Research Opportunities Management, Alexandria, Va., was chosen to serve as the interim secretariat. Beyond this, the participants agreed that the following steps would be taken:

A group of workshop participants considered the "value added" of a specific integrating organization.

- Develop an invitation list based on suggestions given at this meeting
- Convene an initial meeting to further explore community interest in an integrating organization
- Consider an organizational home (i.e., relationship to an existing professional or industry organization) and a secretariat at the initial meeting

2.4 How Do We Get There?

Visions and goals are essential, but in the end, it is results that are measured. How will tomorrow's geo-engineers enhance their status and be recognized as an essential part of a geo-engineering team? More importantly, perhaps, what changes are required to make tomorrow's geo-engineers optimal contributors to U.S. civil engineering, the nation, and the world? Workshop participants defined five fundamental issues on which geo-engineers should concentrate their efforts to produce results.

photo courtesy Louisiana Transportation Research Center

The Louisiana Transportation Research Center uses temperature-controlled creep testing equipment in a project for development of accelerated creep testing procedures for geosynthetics.

Identity, the topic of this chapter, was the first of these five issues. The other fundamental issues are:

- Education
- Research
- Advancing the state of the art/the state of the practice
- Contracting and procurement

Chapter Three

ADDITIONAL WORKSHOP RECOMMENDATIONS

3.1 Education

The U.S. educational process for civil engineers in general, and geo-engineers in particular, was discussed extensively at the workshop. Many participants voiced concern that higher selectivity be exercised by civil engineering departments, noting that quality rather than quantity must be paramount to attract the brightest and best high school graduates into the discipline. Training more civil engineering technicians was advocated as an important and perhaps essential component of civil engineering, including geo-engineering tasks.

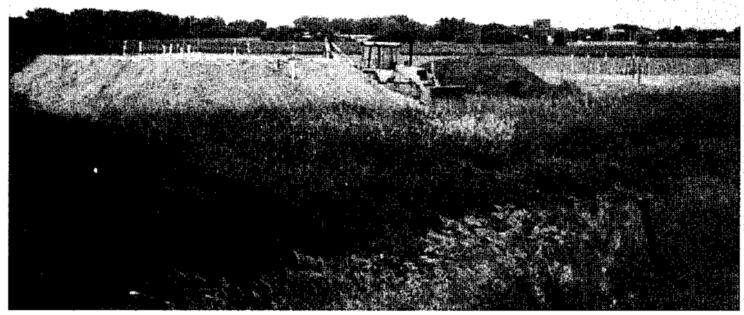


photo courtesy University of Wisconsin at Madison

The National Science Foundation tested an innovative soft ground improvement termed "thermal precompression method" at the University of Wisconsin at Madison. The project compares the compression behavior of peat subjected to ambient ground temperature conditions (15 C) and peat subjected to moderate ground heating conditions (30 C). Moderate ground heating caused a dramatic increase in the rate of creep, followed by a dramatic reduction upon cooling.

The Vision

Educate geo-engineers so they will be able to elevate and sustain the professional practice of geo-engineering in the 21st century.

Strategies

The above vision is buttressed by the strategy that advocates development of a professional geo-engineering degree capable of preparing graduates for technical challenges, providing them with superior communication skills, and introducing them to the business and ethical aspects of the civil engineering profession. At the same time, it will emphasize problem-solving skills and decision-making abilities. Specific action steps were established that complement this strategy, including:

- The ASCE Geotechnical Engineering Division Executive Committee should pro-actively champion geotechnical engineering accreditation at the graduate level similar to what has been accomplished for environmental engineering, for example, through the Accreditation Board for Engineering & Technology (ABET)
- USUCGER should develop continuing education courses for geotechnical engineering faculty
- ASCE Practitioner-in-Residence Program should enhance government/industry/academia exchange and cooperation, (for example, through ASCE's faculty-in-residence program, in which faculty become exposed to engineering office working environments)

- The Institute of Professional Practice should develop an ethics and business management curriculum for geo-engineers
- The National Society of Professional Engineers should endorse the use of continuing education units for continued professional registration

Barriers

- The present ABET structure
- A misunderstood (or misconceived) "technician" concept
- The current interpretation of "Geo-___" as related only to soils

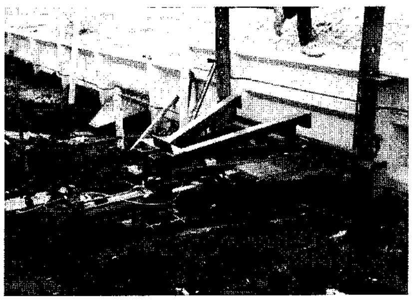


photo courtesy La. Transportation Research Center

The pullout resistance of reinforcement in a full-scale wall is being evaluated by the Louisiana Transportation Research Center.

3.2 Research

Geo-engineering advances in the state of the art and the state of the practice depend on the focus, quality, scope, and technical transfer of relevant research. These are therefore the parameters that framed discussion and the subsequent development of a vision, strategies, and recommended actions for geo-engineering R&D.

The Vision

Through basic and applied research, particularly oriented toward multi- and interdisciplinary approaches, expand fundamental understanding and the knowledge base as necessary to achieve national strategic objectives and address present and future geo-engineering challenges.

Strategic areas for research have already been articulated for geo-engineering. Among the most authoritative is the 1989 work of the Geotechnical Board of the National Research Council, which declared the following areas to be of national importance:

photo courtesy FHWA Turner-Fairbank Hwy. Research Center

At the Turner-Fairbank Highway Research Center, load tests on spread footings are conducted in test pits. Geosynthetic materials are used to reinforce the sand in the pit.

- Environmental control (waste management)
- Infrastructure development and rehabilitation
- Construction efficiency and innovation
- National security
- Resource discovery and recovery
- Mitigation of national hazards
- Frontier exploration and development

Group members noted that significant geo-engineering research must be undertaken to meet known and expected future challenges. They concluded that by 2010 geo-engineering researchers must develop improved methods to:

- Define site characteristics on a real-time basis with a high level of certainty
- Define major soil and rock mass properties non-destructively
- Assess effectiveness of in-situ ground improvements
- Evaluate ground characteristics during construction, i.e., "design as you go"
- Assess fate and transport of contaminants in geo-materials

- Develop cost-effective geo-construction technologies (automation)
- Develop technologies for infrastructure rehabilitation, ground remediation, and difficult site conditions
- Advance analytical abilities
- Retrieve data from global data bases (instantaneously and cost-effectively)

Strategies

Two specific strategies were developed to aid in the accomplishment of the above research thrusts. First, a principal research organization for geo-engineering-related research in the United States should be established. Group members concluded that this research organization must successfully:

- Bring together government, private sector, academic, and research communities to develop consensus on national priorities for geo-materials and systems research and explore and develop funding sources
- Develop links between identified research priorities and national priority issues
- Create a partnership with construction industry leaders (i.e., engineers and contractors) to ensure that "real" problems are being addressed
- Develop cost-benefit relationships that demonstrate the need for research and the payback from investment by the public sector (principally Federal agencies) and private industry
- Develop venues for periodic reporting of research progress, major developments, updated research priorities and, equally important, the creation of public awareness and recognition of both progress and benefits

Group members noted that significant geo-engineering research must be undertaken to meet known and expected future challenges.

The second strategy addressed the essential but difficult challenge of implementing geo-engineering research into practice. Group members concluded that technology transfer should be vigorously promoted through interdisciplinary and multinational cooperation and collaboration.

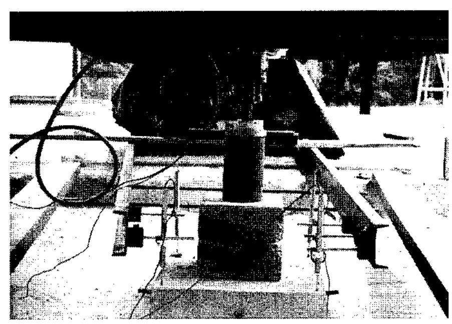


photo courtesy FHWA Turner-Fairbank Hwy. Res. Center

A load test being conducted on a footing.

The components of a research action plan were identified as requiring at least the following specific actions:

- Identify a lead organization to provide leadership for geo-engineering research (perhaps a broadened USUCGER)
- Establish a group of representatives from industry, government, and academia to identify and prioritize national research needs—confirm or revise earlier Civil Engineering Research Foundation prioritization effort, *Regional Research Needs in Geotechnical Engineering* (CERF Report No. 91-F1002.E)
- Develop a construction industry research institute exchange program.
- Identify contacts within the Federal government and key state and local agencies
- Conduct cost-benefit studies to demonstrate the value of research investment in construction research

Figure 2

Barriers that impede advancing the state of the art:

Limited monetary resources (government, private sector, and academia)

Lack of interdisciplinary cooperation to solve complex problems

University faculties with no practical experience

Perception of practice-oriented research as not academically "worthy"

Incomplete bridging of theory and practice

Constructability issues

No significant benefit perceived from any efforts to advance state of the art/state of the practice

"Right" problems not addressed

Significant barriers to improving the current state of the practice:

Resistance to change among designers, owners, agencies, regulators and codes, politicians, producers, and contractors

Costs relative to perceived benefits (ratio)

Incomplete or missing performance data

Liability

Risk

Education

Contracting process and procedures

Lack of incentives

Transition barriers from state of the art to state of the practice:

Demonstration of feasibility

Demonstration of long-term performance

Perception of risk (success/performance)

Unsucessful marketing

Newly-developed, state-of-the-art practices are not incorporated into educational courses and programs

Inadequate continuing education

- Issue an annual report summarizing research accomplishments and future research needs
- Develop a comprehensive public awareness plan, including multimedia, newspaper, magazine, television specials, classroom videos, and media events
- Prepare, and update as appropriate, a report identifying and summarizing cutting edge technologies as is done in other fields (e.g., medicine)

3.3 Advance State of the Art/ Improve State of the Practice

Five issues were identified in this workshop as being critical to the future of geo-engineering; while four are relatively independent, one is not. How the state of the art/state of the practice unfolds in the years to come will be heavily influenced by the progress made in education, research, contracting and procurement, and, indeed, in clearly defining identity for this engineering discipline.

Focus group members developed a challenging vision statement that merges "art" and "practice."

The Vision

To foster the state of the art and state of the practice, closing the gap between the two until no geotechnical reason exists that any project cannot be built on any site.

The group quickly moved from vision to practical realities by focusing on barriers that impede the "closing of the gap." Barriers were considered sequentially, moving from those that impact the state of the art to those that influence the state of the practice. The total set of barriers is captured in Figure 2.

Strategies

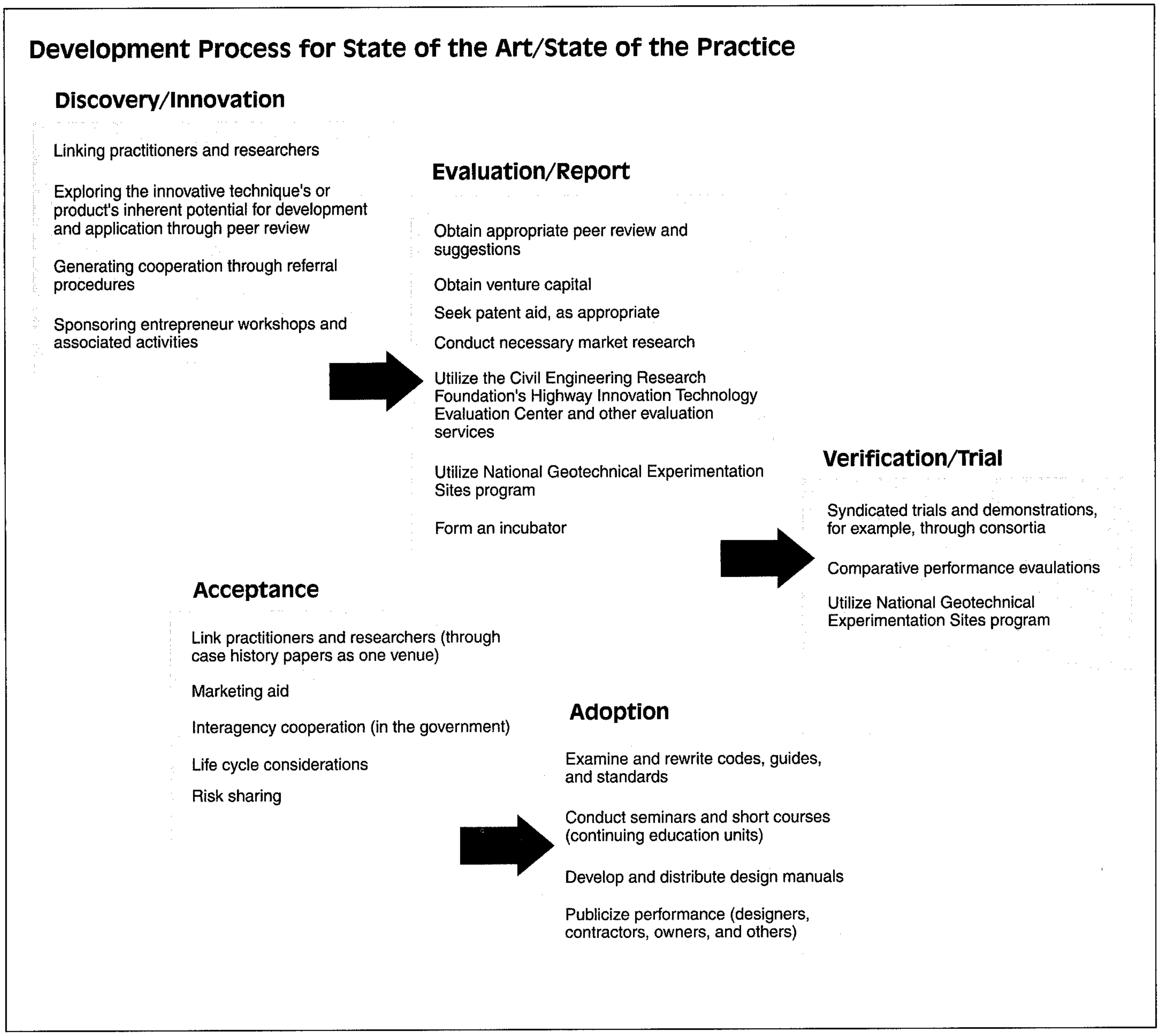
With the benefit of a vision and the identification of barriers, group members turned next to the development of a strategy. The strategy that emerged seeks to:

Improve the geo-engineering process by identifying the barriers and modifying or facilitating the process to achieve efficiency and decreased cycle time.

The principles of total quality management and empowering employees were viewed as important components in implementing this strategy.

Development of the strategy led also to the defining of the process. The states of this process were further defined through "essential activities" for each of the

Figure 3



links that comprise this process. These links and their associated activities are depicted in Figure 3.

Vision and strategy led the group toward action planning. Two possible plans were initially developed, one anchored in the technical committees of the American Society of Civil Engineers Geotechnical Engineering Division and in the use of total quality management principles. The second alternative would convene workshops to identify needed improvements to the process. Follow-up workshops would develop action and execution plans. Later, determining how to sustain the effort would be considered.

In the end, a third alternative that merges the two proposed alternatives into one action plan was chosen. The organizations most suitable to lead the efforts were identified as follows:

ASCE
Form taskcommittee to develop action items on implementation plan

CERF and ASFE
Set-up workshops on removing liability and risk as barriers to acceptance of new technology

CERF
Fully implement results of Civil Engineering Research Foundation's 1991 report on *Regional Research Needs in Geotechnical Engineering* (CERF Report No. 91-F1002.E)

Contracting and procurement procedures must become complementary assets in the quest for quality rather than liabilities.

3.4 Contracting/Procurement

The selection of contracting/procurement as a fundamental issue for geo-engineers and geo-engineering is instructive—it highlights the very real challenges posited by the currently practiced contracting and procurement procedures in the United States. Moreover, it reinforces the extensive earlier discussion of this serious barrier by the former Geotechnical Board of the National Research Council.

In a 1989 report issued by the Geotechnical Board, *Geotechnology, Its Impact on Economic Growth, the Environment, and National Security,* traditional contracting practices were seen as an institutional constraint that makes the introduction of new design and construction techniques more difficult.

> Typical contracting practice involves separate contracts for geotechnical investigation, design, construction, construction management, and operation. Short-term attitudes often lead to cheap investigations and cheap designs at the front end of the project that ultimately produce expensive construction, operation, and maintenance problems. Problems are introduced as a result of the contracting arrangement as well. Separate contracting practices generally result in the introduction of conservatism at each level of the project. If the designer anticipated some involvement during construction, he or she might feel more comfortable with an innovative approach to solving geotechnical problems. What is needed is a long-term systems approach and coordinated design/construction/maintenance contracting arrangements.


photo courtesy Hayward Baker

A worker performs a slump test.

The Vision

Drive the contracting/procurement process toward quality in the constructed project.

As the above vision asserts, contracting and procurement procedures must become complementary assets in the quest for quality, rather than liabilities. To this end, the strategy crafted by the workshop participants places responsibility on geo-engineers to lead, namely:

All members and firms in the geo-engineering practice should take a leadership role in applying existing and emerging procedures for contracting/procurement to optimize quality and costs in the constructed project.

How is this to be done? Nine specific action steps were developed, with each assigned to a suggested lead organization or several organizations, including, in six of the suggested actions, a potential integrating geo-engineering organization. The plan components and proposed lead organizations are:

- Support quality-based selection in professional services procurement (lead: Professional Firms Practicing in Geosciences/integrating organization)
- Endorse the continuity of geo-services; especially in alternative contract/procurement methods. (lead: Professional Firms Practicing in Geosciences/integrating organization)
- Promote and encourage the use of Professional Firms Practicing in Geosciences's Institute of Professional Practice - Project Delivery System Training material for the training of young engineers and students (lead: Professional Firms Practicing in Geosciences/integrating organization)
- Educate practicing engineers and industry on the advantages and disadvantages of alternative project delivery methods (lead: American Society of Civil Engineers)
- Promote and participate in emerging dispute resolution procedures (lead: American Society of Civil Engineers/ integrating organization)
- Create a task group to develop new procurement mechanisms, such as: owner selected team; warranties; owner/contractor manager; design, build, maintain, and operate (lead: Civil Engineering Research Foundation/integrating organization)
- Promote constructability reviews at appropriate project stages (lead: ADSC: International Association of Foundation Drilling and DFI)
- Identify and contact organizations that might oppose alternate contracting/procurement and effectively communicate benefits (lead: integrating organization)
- Encourage Federal agencies to solicit and collect case histories describing alternate contract delivery systems (ADSC: International Association of Foundation Drilling)/report to Congress and the Executive Branch Administration (lead: Civil Engineering Research Foundation)

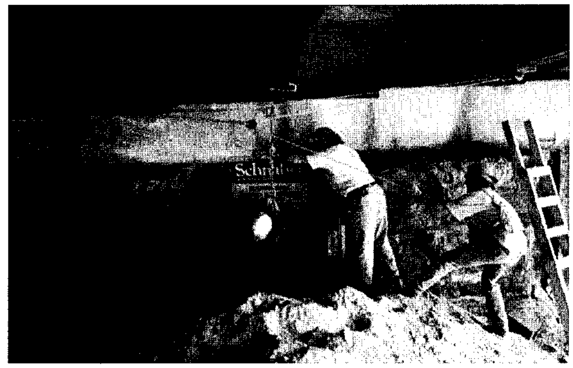


photo courtesy ADSC: The International Assn. of Foundation Drilling

Prior to starting excavation work under the I-285 overpass in Atlanta, Ga., crew members of the Schnabel Foundation Company practiced confined space rescues using lifelines and pulleys.

POSTSCRIPT: THE PATH AHEAD

The workshop resulted in recommendations whose impact is potentially far-reaching for geo-engineers and the nation. Moreover, it generated an enthusiasm and commitment to change among participants. Participants want to see positive changes and progress, changes that will lead the nation's geo-engineering community toward the accomplishment of the visions articulated in this workshop. The groundwork has been laid through this workshop; the parameters for continued effort must still be determined. Two tangible future efforts were defined: first, the continued existence of the workshop steering committee (through the cooperative efforts of the National Science Foundation and Federal Highway Administration, among others) and a second, follow-on workshop, larger in scope and attendance with, as appropriate, an international perspective.

Other national efforts, for example, the ASCE's efforts to create an affiliated organization for geotechnical engineering, and the efforts of the Construction and Building subcommittee within the National Science and Technology Council appear to complement and reinforce the work accomplished through this workshop. Geo-engineering leaders should therefore seriously consider linking progress to efforts such as the two noted above. Such efforts promise to provide a framework through which the geo-engineering community can anchor specific actions and programs and through which progress can be charted.

This workshop was an important step for U.S. geo-engineering and U.S. geo-engineers. It has followed and built upon other geo-engineering efforts. Participants, as a whole, trust that the visions that were created will be the stimuli and springboards for future efforts that ensure geo-engineering's optimal contribution to the profession of civil engineering, the nation, and the world.

REFERENCES

Civil Engineering Research Foundation, *High-Performance Construction Materials and Systems: An Essential Program for America and Its Infrastructure,* Executive Report, Report 93-5011.E, American Society of Civil Engineers, N.Y., April 1993.

Civil Engineering Research Foundation, *Regional Research Needs in Geotechnical Engineering,* Report 91-F1002, American Society of Civil Engineers, N.Y., June 1991.

The Geotechnical Board, *Geotechnology, Its Impact on Economic Growth, the Environment, and National Security,* National Academy Press, Washington, D.C., 1989.

APPENDICES

Appendix A
ACRONYMS

ABET	Accreditation Board for Engineering & Technology
ADSC	The International Association of Foundation Drilling
AEG	Association of Engineering Geologists
AOSC	Association of Oilwell Servicing Contractors
ASCE	American Society of Civil Engineers
ASCE GTD	American Society of Civil Engineers Geotechnical Engineering Division
ASCE GT EXCOM	Geotechnical Executive Committee
ASFE	Professional Firms Practicing in the Geosciences
ASTM	American Society for Testing and Materials
AUA	American Underground-Space Association
C/P	Contracting/Procurement
CERF	Civil Engineering Research Foundation
CEU	Continuing Education Units
DFI	Deep Foundations Institute
ENR	*Engineering News-Record*
FHWA	Federal Highway Administration
GRI	Geosynthetic Research Institute
HITEC	Highway Innovation Technology Evaluation Center
IGS	International Geosynthetics Society
IPP	Institute of Professional Practice
NAGS	North American Geosynthetic Society
NASTT	North American Society for Trenchless Technology
NGES	National Geotechnical Experimentation Sites
NSF	National Science Foundation
NSPE	National Society of Professional Engineers
NSTC	National Science and Technology Council
PAC	Political Action Committees
QBS	Quality-Based Selection
SOA	State of the Art
SOP	State of Practice
TAC	Technical Activities Committee
TQM	Total Quality Management
USCOLD	United States Committee on Large Dams
USUCGER	United States Universities' Council on Geotechnical Engineering Research

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Appendix D

WORKSHOP COORDINATOR ARA ARMAN'S OPENING REMARKS

Ladies and Gentlemen:

I am honored and very pleased to welcome you to this most unusual and pivotal workshop. On behalf of the workshop organizing committee, I thank you for taking time from your very busy schedules and away from your loved ones to perform a crucial and unique task for the civil engineering profession.

We are here today because of the vision, concern, and resourcefulness of two distinguished members of our professional community: Dr. Mehmet Tumay and Mr. Al DiMillio. Dr. Tumay, who is completing an assignment of four very creative and productive years at the National Science Foundation, and the Federal Highway Administration's highly respected and progressive geotechnical engineer, Mr. Al DiMillio, teamed to consider their observations on diminishing recognition of geo-engineering and lack of a well-defined, holistic vision to guide and shape the future of the discipline. They set out to inform their colleagues that the geo-engineering discipline may be globally facing an identity crisis. A crisis that may threaten the survival of the discipline in the 21st century.

They expressed their thoughts and concerns to CERF, which recognized the need to provide the leadership for the consideration of the issues. As another one of CERF's continuing services to civil engineering, CERF brought together a group of volunteers in a committee to deliberate the topic. After much discussion at various meetings throughout the last six months, it was decided that a workshop needed to be organized to evaluate the current status of geo-engineering, to review the past and the changes that have taken place since the publication of the *Erdbaumechanik* in 1925. To be followed by an examination of the role of our profession and discipline in the overall changing society, and mapping out new directions and requisite guidelines to clearly identify the role of geo-engineering in the 21st century.

Geo-engineering was and still is an exiting, invigorating discipline. Full of challenges, full of unknowns, each project large or small presents a new facet of the geomedia we work with. There is that unknown factor in all of our work. The giants of our practice, Terzaghi, Peck, Casagrande, and many contemporaries, some of whom are with us this morning, through their dedication, diligence, and thorough understanding of the media have transformed the soil and foundation technology to a scientific discipline of engineering.

They have taken it through stages of higher scientific sophistication into the discipline of soil mechanics, to geotechnical engineering, to geo-engineering. We have throughout the last half of the 20th century learned to mathematically, and quite realistically, model the behavior of soil and rock. We have learned to design and build massive earthen structures, such as dams, that resist nature's quiverings. We have connected continents through the safe and effective use of underground space, and we have assumed significant roles in the solution of environmental problems and in the protection of the environment. Through the creativity and tenacity of researchers and manufacturers of materials, instruments, and equipment, we can now successfully manipulate properties of soil and rock and add synthetic ingredients to improve their properties. We have come a long way in the placement and improvement of soils and rock, the geomedia.

I have this morning repeatedly used the term geo-engineering and geomedia. I realize that these are not "officially" sanctioned terms, however, in the past as the role and the universe of soil mechanics have widened, its name, either by default or by design, has changed to reflect its new role and universe. Many of us in the last decade have used the term geo-engineering, which perhaps does not clearly identify our discipline but it certainly reflects the more global involvement of geotechnical engineers in shaping today's world.

Whether it is earthquake geotechnics, geotechnics of coastal materials, the frozen tundra, contaminant transport, or the soils of the moon, it is geoengineering . . . or perhaps it is time to coin a new and more representative term for our changing practice!

At the beginning of my introduction I mentioned that this was to be a unique workshop, and indeed it is. First of all, it is unique because you are a very special group of leaders in geoengineering. And what is needed in this workshop is the collective wisdom of the leaders to prepare our entry into the 21st century with vigor and renewed dedication for the betterment and sustaining of our society. Secondly, it is unique because you are here to fix something that does not appear to be broken. As the old saying goes maybe "if it ain't broken don't fix it."

In 1955, as a young man, when I crossed the Atlantic ocean for the first time, I did so on a propeller-driven plane. It took off from Paris, stopped for refueling at Shannon, Ireland, and flew to Gander, Newfoundland, for another refueling. After 26.5 hours it made it to New York's Idelwild airport. After another overnight trip I finally arrived in Dallas, Texas. From there a genuine cowboy, who appeared to be riding a bronco on clouds took me to Austin, to my destination. Wow! What a trip. It was awesome! Instead of ocean liners that took six or seven days to cross the Atlantic we flew across in a little more than one day. Instead of a steam locomotive pulling a train to Texas I flew overnight! We were all thankful for those technological marvels: the propeller planes.

Aeronautical engineers and scientists and entrepreneurs, however, were not satisfied with their accomplishments; they were hard at work to fix something, to better something that was not broken. As a result came new generations of the turboprop planes that flew faster . . . and then came the jet-propelled planes. They flew not only faster but higher, on less fuel, with heavier loads.

Today we can have breakfast in Washington, D.C., and be in Paris to have dinner and take in the opera the same night because the human spirit is not and never will be satisfied with "if it ain't broken don't fix it."

I submit to you, ladies and gentlemen, that we are here today to find the way for our exciting and challenging profession to soar higher, to grow stronger . . . to ensure its just place and recognition among sciences and professions.

I wish all of us success in this noble endeavor.

photo courtesy Xerox Document University

Approximately 50 of the nation's geo-community experts gathered at the Xerox Document University in Leesburg, Va., May 20-21, 1994, to analyze the current role of geo-engineering in the larger framework of civil engineering.

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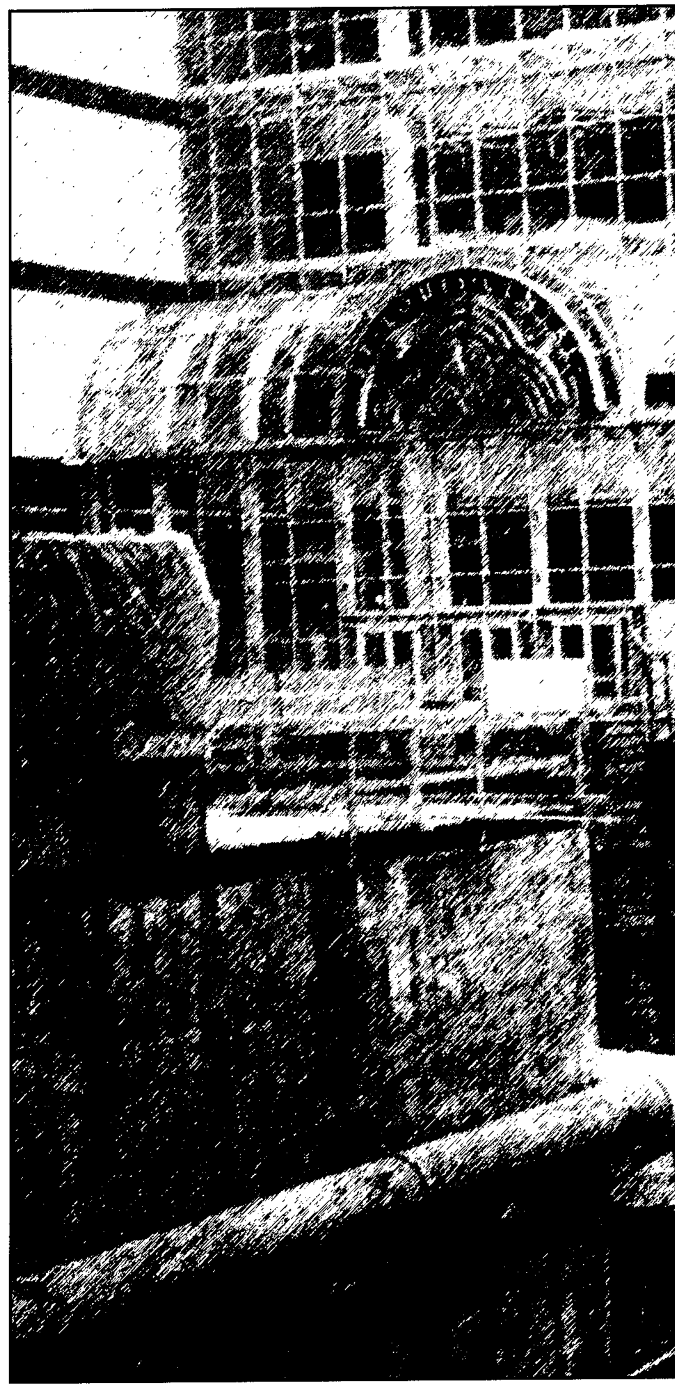

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